Surgical Skill Evaluation for Endoscopic Sinus Surgery

Computer Integrated Surgery II
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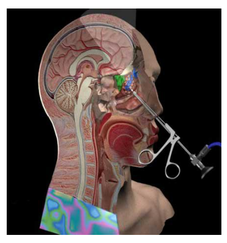
Introduction



- The goal of this project is to mathematically model the motion of the tip of endoscope in an endoscopic sinus surgery to be able to determine the skill level of a surgeon and further our knowledge in the area of Language of Surgery

The major deliverables for this project include:

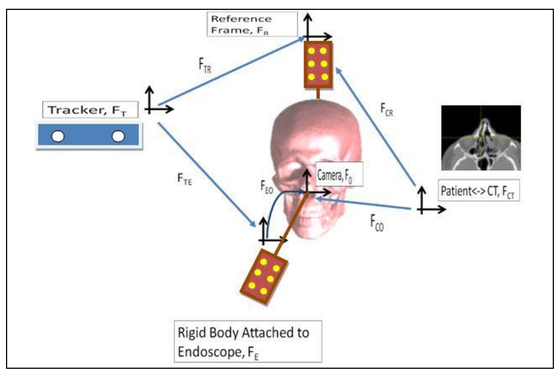
- A recording software to record the endoscopic video and the tracker data from a surgery.
- A registration algorithm to register the motion of the tip of the endoscope to the CT frame.
- Manually segment the motion into different movements for further data analysis.

The Problem

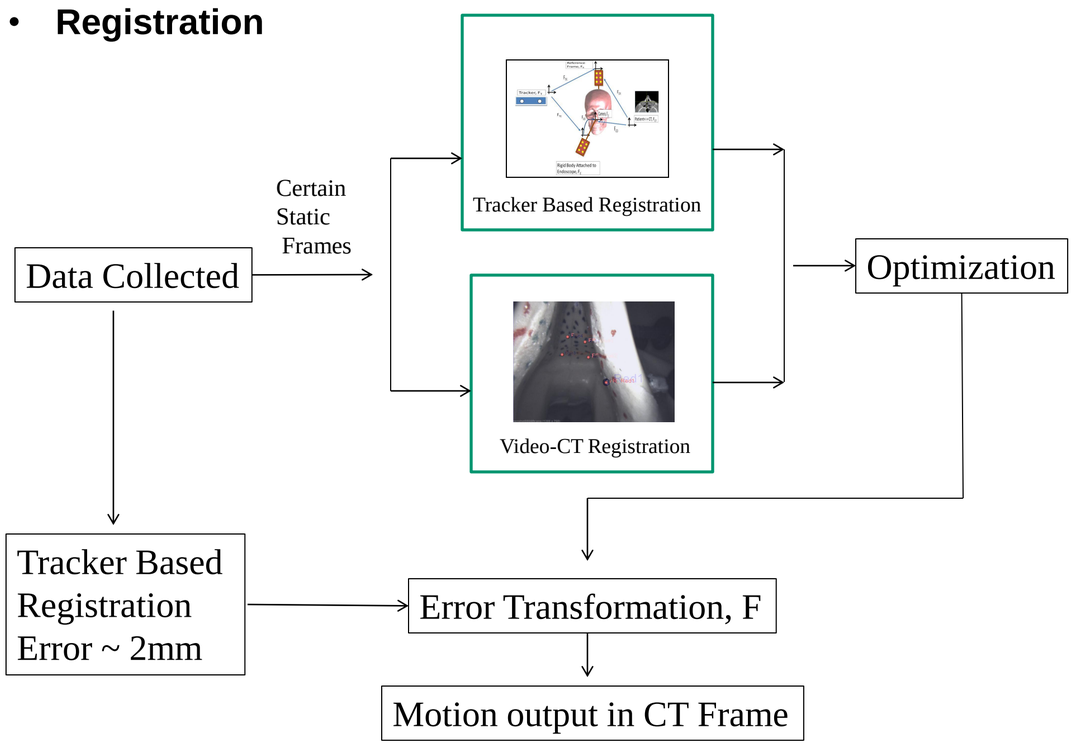
- The sinus anatomy is in vicinity of critical regions like carotid artery which supplies blood to the brain and optic nerve.
- Thus the surgical procedure involves a lot of critical movements to be performed by the surgeon.
- We want to develop a model that will evaluate how well these critical movements were carried out.
- This model will help train the surgeons better providing them quantitative feedback on their movements during the surgery.

The Solution

- To evaluate surgical skill level, we will be modeling the motion of the tip of the endoscope in the CT frame of coordinates through the entire procedure.
- **Data Collection**
  - The OR Setup to obtain the data is shown below. The tracker used in the setup is the Medtronic Stealthstation.



  - The recording software was written using libraries from Medtronic and CISST stereovision library to record the endoscopic images and the tracker readings for the complete procedure.
- **Registration**

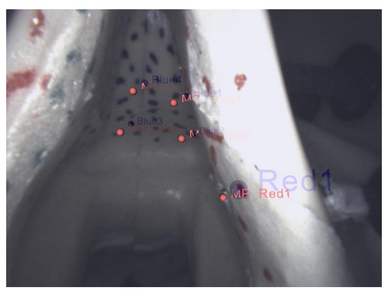


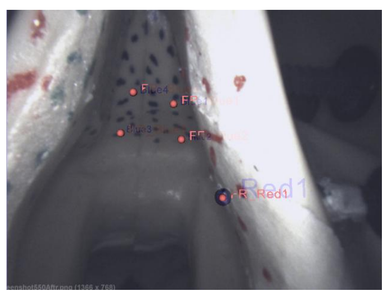
Segmentation

- Manually segment the motion into different tasks done during the surgical procedure.
- For each task, transform the coordinates from CT frame to a frame corresponding to a particular landmark in the anatomy to maintain consistency between recordings from different patients.

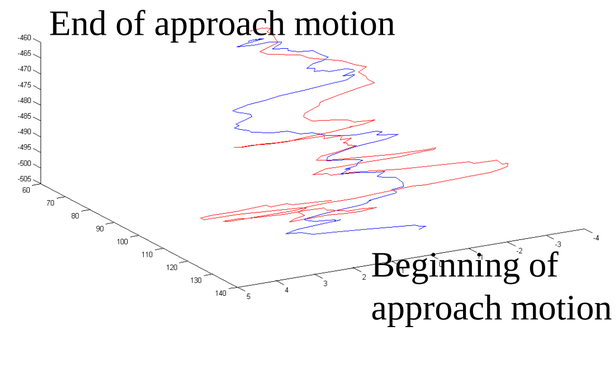
Outcomes and Results

- The complete algorithmic procedure was tested on the recording done on a phantom.
- Figure below shows the result of 2D-3D Registration between manually segmented landmarks in endoscopic image and CT respectively. Here image on the left shows the pose of the camera before registration and the image on the right shows the pose of the camera after registration





- After Registration Optimization, the change in the mean error for 5 different static frames was as follows:
  Initial Error in each coordinate direction (in mm) =
  2.1816 2.1214 1.1958
  Total Error: 3.2695 mm
  Final Error in each coordinate direction (in mm) =
  0.9283 1.2236 0.9067
  Total Error: 1.7835 mm
- Figure here shows the motion plots for approach into the sinus cavity.



Future Work

- For final deployment, the project would require finalizing the complete approach towards registration, segmentation and training.
- The next step is to record data from surgeries by skilled surgeons, follow the approach described above and segment the motion data into respective tasks.
- For each of these tasks, train a classification model with data from expert conducted surgeries.

Lessons Learned

- When developing a software on windows using libraries and codes from various sources, always check the compatibility between different versions and with libraries from VS.
- The quality of Landmark based 2D – 3D registration depends largely on the selection of landmarks for the registration. Hence very careful selection of anatomical landmarks is required. Ideally, a set of landmarks that are able to constrain the endoscope position in all degrees of freedom would be required.

Acknowledgements

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References

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